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HUMAN FACTORS ASSOCIATED WITH RUNWAY INCURSIONS

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Introduction

Though few aircraft collisions have occurred on or immediately above runways at controlled airports, incidents involving incursions of aircraft or surface vehicles into aircraft movement areas have been a continuing source of concern to those responsible for management of the national aviation system. In response to requests from the National Transportation Safety Board and the Federal Aviation Administration, a study has been conducted of ASRS reports relating to such incursions. This study was not designed to provide quantitative data regarding the prevalence of such occurrences; rather, it was focused on the behavioral aspects of potential and actual conflicts on controlled airports. The reports which were used in the study were submitted between July 1, 1976 and June 30, 1978, a period of 24 months. This report is a summary of the findings to date in the study, which is continuing. A final report will be published separately.

Approach

Dimensions of the study— The study examined 165 potential conflicts, actual conflicts, and situations which under other circumstances could have resulted in conflicts on or immediately above the aircraft movement areas of controlled airports in North America. The search of the ASRS data base was not inclusive for such events; it is known that not all reports relating to or describing such events were retrieved by the search strategies employed. Nonetheless, enough relevant reports were retrieved to permit a systematic study of the characteristics and dynamics of such occurrences.

Categorization of occurrences— Each report was categorized as to each of the following characteristics:

1. Month of occurrence
2. Location
3. Reporter
4. Types of aircraft involved
5. Types of operation involved
6. Phase of flight
7. By whom the occurrence was initiated
8. Occurrence type
9. Type of conflict
10. Outcome of occurrence
11. By whom recovery was initiated
12. Recovery actions by each participant
13. Enabling factors

These categories are defined and explained as they are discussed. All occurrences were assumed to involve human error; although there were a few cases in which mechanical or environmental factors were important, the assumption proved to be generally valid.

Analysis of the data— All reports were categorized as described above. After the categorizations were checked for accuracy, the reports were re-read and enabling factors were added. The analysis thereafter was designed to examine associations among descriptive and enabling factors, with the hope of answering the following questions for as many occurrences as possible:

1. Where did the event occur? When? What happened?
2. What errors, by whom, contributed to the occurrence?
3. What were the characteristics of the occurrence?
4. Who first recognized the problem? How was recovery effected?
5. What factors were associated with the occurrence? In particular, did certain human or system factors tend to be associated with particular occurrence characteristics?

Results

Initial evaluation of the reports indicated that 30 of the 165 occurrences involved no conflict. This category was assigned when only one aircraft was involved in the occurrence; there was no potential conflict with another aircraft or vehicle because there was no other vehicle in the vicinity. The remaining 135 reports did involve a threatened or actual conflict.

Month of occurrence— Somewhat more reports were noted during spring, summer and fall months than during the winter. The differences were not striking.

Locations— The 165 occurrences took place at 73 different locations. Five or more occurrences were reported at nine hub airports. Specific location data will be discussed in the final report of this study.

Reporters— Pilots and crewmembers provided 66% of the occurrence reports; controllers reported 32%; other persons provided 2%.

Types of operations— While a simple listing cannot fully account for operational types in those cases involving more than two aircraft or vehicles, table 1 shows types of operations, where known, for the 135 cases involving a potential or actual conflict between aircraft.

TABLE 1.— TYPES OF OPERATIONS IN CONFLICT OCCURRENCES

Operator classes in conflict occurrence	Number of occurrences
Air transport/air transport	41
Air transport/general aviation	29
Air transport/military or government	3
Air transport/other or unknown	36
General aviation/general aviation	7
General aviation/military or government	2
General aviation/other or unknown	13
Other or unknown/other or unknown	4
	<u>135</u>

Initiators of occurrence— As noted above, it was assumed that all these occurrences involved human error. The person believed by the authors to be responsible for the initial error associated with the occurrence was the controller in 54% of 165 occurrences, the pilot in 39% of the occurrences, and the operator of a surface vehicle in 4% of the occurrences. In five cases (3%), the data did not permit categorization.

Outcome— An occurrence was classed as a near collision if, in the opinion of the authors, two vehicles came perilously close to colliding. This, of course, depends on the size, type, and speed of the vehicles, as well as their relative courses, all of which were taken into account. Unless it was fairly certain that the event was a near collision, it was classified as "less than safe separation" if a conflict occurred, or "recognized error" if one or more persons recognized the problem and took action in sufficient time to prevent a conflict. Other cases were classified as "no conflict."

One occurrence involved a collision (wing tip with motor vehicle); 37 involved near collisions; 50 involved less than safe separation. In 47 cases, the problem was recognized before a conflict occurred. There was no actual or threatened conflict in 30 cases, because no other aircraft or vehicle was in the vicinity.

Phase of flight— The flight (or ground operation) phases for the two aircraft principally involved in aircraft/aircraft conflicts are shown in table 2 for all cases in which two aircraft were involved and in which both phases were known.

TABLE 2.— PHASE OF FLIGHT AT TIME OF OCCURRENCE

Flight phase, aircraft 2	Flight phase, aircraft 1 ^a					
	Hold	Taxi	Takeoff	Approach	Land	Other
Hold	0	6	1	4	4	0
Taxi		3	21	8	14	1
Takeoff			8	7	11	0
Approach				1	1	0
Land					8	2
Other						0

^a Figures are percentages of sample.

It is worth noting that the two most frequent categories for both pilot- and controller-initiated incidents were taxi/takeoff and taxi/land. The other major categories were takeoff/land, takeoff/takeoff, land/land, and taxi/approach.

Occurrence types— The 135 occurrences which involved conflicts were classified as shown in table 3. The data are summarized for occurrences initiated by pilots and by controllers.

TABLE 3.— RUNWAY INCURSIONS: OCCURRENCE TYPES

Pilot occurrences		Controller occurrences	
Lack of clearance to:		Failure to insure separation:	
Cross a runway	33%	Intersecting	47%
Take off	23	In trail	24
Land	6	Other	12
Taxi to ramp	2	Confusion	9
Disorientation/confusion	21	Lack of information	4
Confusion about clearance	2	Late clearance change	3
Other	13	Other	1
	100%		100%

Recognition of problem— The problem was first recognized and recovery action initiated, by a pilot in 50% of 135 cases; recognition was by a controller in 25% of the cases. Simultaneous recognition and action by controller and pilot occurred in 3%; there was no recognition of the problem in time to take recovery action in 20%, and in 2% of the cases the data were inadequate to permit categorization.

Enabling and associated factors— The factors that were assigned to reports containing enough data to permit such analysis, together with their frequency of occurrence in events believed to have been initiated by pilots and controllers, are shown in table 4. As many factors as were believed pertinent were assigned to each occurrence.

Occurrences initiated by drivers and those in which the initiators of the occurrence could not be determined are not included in table 4.

It should not be inferred that the factors in table 4 are inclusive of all factors pertinent to the cases under study, nor should it be inferred that each factor listed was necessarily causal in the occurrences. Rather, the factors listed are in the best judgment of the authors, pertinent to the occurrences, based on the information available in the reports.

It is interesting to note certain apparent anomalies in the list. Controller technique was cited as a factor in nine reports in which a pilot error apparently initiated the occurrence. Similarly, pilot technique was cited in 11 controller error reports. These findings and certain others like them are discussed below.

The enabling and associated factors were partitioned by occurrence type and outcome in an effort to find whether certain types of occurrence, or certain outcomes, are associated with particular human and system factors. The results of these analyses are discussed below.

TABLE 4.— ENABLING/ASSOCIATED FACTORS IN RUNWAY INCURSIONS:
65 OCCURRENCES INITIATED BY PILOT, 89 BY CONTROLLERS

Factor	Occurrence initiated by:	
	Pilot	Controller
Coordination problem in cockpit	11	0
Coordination problem between aircraft and ATC	17	19
Coordination problem within tower	3	29
Coordination problem between tower and approach control	1	8
Phraseology	3	2
Language problem	3	1
Frequency congestion	3	3
Similar flight numbers	1	0
Controller technique	9	61
Pilot technique	43	11
Intersection takeoff	2	4
Landing to hold short of intersection	0	2
Airport lighting and markings	4	3
Airport, other factors including staff	3	7
ATC and controller procedures	3	8
Pilot/flight procedures	7	1
Training in progress	0	5
Environment (weather)	4	6
Workload	3	2
Fatigue	0	1
Other factors	0	2
Total factors	120	175

Discussion

Introductory comments— Unplanned incursions onto aircraft movement areas represent a serious potential threat to system integrity. In this sample of occurrences, 82% represented at least a potential conflict; there was an actual conflict in 53%, a near collision in 22%, and an actual collision in 1%. Air carrier aircraft were involved in 81% of the potential and actual conflicts.

Virtually all the occurrences involved human error. In at least 13%, both controller and pilot errors were involved. In 65 occurrences initiated by pilot actions, 64% involved a lack of clearance to perform some maneuver. Eighty-three percent of the 89 occurrences initiated by controller action involved a failure to insure separation.

There was no difference between the two groups with respect to outcome: 22% of both pilot- and controller-initiated occurrences resulted in a near-collision.

There is no question (table 3) that a substantial majority of both pilot- and controller-initiated occurrences involved deficiencies in technique. Failure to obtain a clearance, for whatever reason, is a deficiency in pilot technique; failure to maintain assured separation, for whatever reason, is a deficiency in controller technique. It is hardly surprising, then, that the most commonly cited enabling/associated factor in table 4 is a technique deficiency. This citation, however, is hardly enlightening unless accompanied by information that suggests why the break in technique may have occurred. The remainder of this analysis is devoted to this question.

Pilot-initiated occurrences— Although pilot technique was involved in most of these occurrences (43 of 65), it is necessary to ask what other factors were also present and pertinent to the event (table 4). One notes that coordination problems were cited 32 times; most of these involved within-cockpit or cockpit-ATC coordination, though in 4 cases, there was an associated coordination problem within ATC.

Typical breakdowns in cockpit coordination are illustrated in the following examples.

On taxi out, we were issued a clearance to taxi to runway 27L. Normal departure runways are 26 and 27R with landings on 26 and 27L. There is extensive airport construction which causes extensive diversions while taxiing. After crossing runway 26 we were given multiple taxi instructions during the process of running the taxi checklist. My attention was evidently diverted when we were given instructions to hold short of runway 27R. The first officer rogered. We were following another aircraft and as we approached 27R we were told to switch to tower frequency. We did so as the aircraft ahead was crossing 27R. I hadn't heard the instructions to hold short, nor had I heard the previous aircraft being cleared to cross. I continued to cross 27R, not thinking of it as an active landing runway, and the first officer didn't caution me to stop. . . . My first knowledge that we were crossing an active runway came when, just as I was approaching the runway, I looked left and noticed an airliner on about a 1/4-mile final. I could have slammed on the brakes and stopped short of the runway, but feeling that I had plenty of time to cross and not wanting to injure a flight attendant with the sudden stop, I simultaneously asked the first officer if we had been issued clearance to cross (he replied that we had not) and proceeded on across. The tower directed the airliner to go around which I didn't think was necessary but from his vantage point I'm sure he acted according to his own best judgment. . . .

In the following case, the initial portion of the taxi clearance was transmitted during rollout. As we have noted in earlier reports, both cockpit noise levels and flight crew workload are high at this time. ASRS reports continue to describe misunderstandings of clearances delivered during this phase of flight. It appears that some controllers are not sufficiently aware of this problem.

After landing on runway 10R, we were advised by tower to turn off runway 10R onto runway 5 and to hold short of runway 14. While decelerating the aircraft and turning off runway 10R, I failed to hear the instructions to hold short of 14. As we approached the intersection of runway 14, the first officer said "hold short." and

I stopped the aircraft short of the runway. We would have collided with another airline aircraft had not the first officer advised me to hold short. He later told me that he had also applied brakes. The major factor in this occurrence is that I failed to hear the clearance limitation. Also, I was not completely familiar with the closeness of runway 14, having never landed on 10R before. I am aware that affirmative clearance is required to cross a runway and would have stopped notwithstanding the failure to hear the clearance to hold short had the intersecting runway been clearly recognizable as a runway.

Cockpit-ATC coordination problems usually involved either misunderstandings between pilots and controllers, inadequate information transfer, or nonstandard procedures or phraseology.

The pilot of aircraft A had been issued clearance for takeoff on runway 27 while taxiing out from the loading ramp . . . the A pilot had just completed engine start and was not yet on tower frequency when the clearance was given. The STOL aircraft was on another ramp approximately 250 ft from the taxiway-runway intersection normally used as the initial takeoff position by STOL aircraft. The instructions which were seemingly received were that he was cleared for takeoff. He reached the intersection at approximately the same time as A started its takeoff roll. The tower immediately ordered B to clear the runway and A to abort his takeoff. Reaction was immediate and a collision was averted by a good margin.

* * *

. . . After push-back, I was cleared for taxi with the following phrase: "Cleared to taxi runway 8R via Charlie-4 and hold short of runway 8L." The weather at the time was rain showers and an overhead thunderstorm. Runways were wet. After passing the "Bravo" complex and approaching taxiway C-4, we received further instructions, "go right on out there at Charlie-4." I interpreted this to mean that I was cleared to cross runway 8L and proceed to 8R. However, as a precaution, I asked the copilot to check. He was unable due to frequency congestion. Prior to entering the runway, I checked visually and spotted aircraft B on short final for landing on runway 8L. A panic stop was initiated using brakes and reverse. Due to the wet conditions, the anti-skid cycled continuously. The aircraft was turned slightly to the right to present a smaller target to the landing aircraft. After we came to a complete stop, the controller said something to the effect, "You stopped pretty close to the runway." I repeated his previous instructions regarding going out on Charlie-4 and he replied, "I told you to hold short. . . ."

In one case, it is questionable whether the pilot communicated his intentions, or whether he was affected by a wind shear late in the approach.

We were awaiting departure on runway 8R on taxiway. Airline aircraft B in position on runway holding for takeoff clearance. Flight check aircraft approaching runway on final, checking back course approach. Tower advised aircraft B to hold in position. Flight check aircraft continued approach to end of runway at a low altitude, then suddenly deviated downward from flight path and passed over the top

of aircraft B, clearing the aircraft by about 20 ft; he then executed a pull-up maneuver. Aircraft B was unable to see the incident since it was approached from the rear; our crew felt that an impact was imminent for an instant. . . .

Pilot procedures, especially visual monitoring procedures, were inadequate in seven cases. The following examples are typical of the consequences of failure to monitor outside the cockpit even after receipt of a clearance.

Airline aircraft B landing on runway 28R; I was landing on 28L. Airline aircraft B was told by tower to use taxiway Echo, hold short of 28L. Aircraft B didn't even slow down but just taxied across 28L in front of me. If he'd looked out his window, the captain would very easily have seen me boring down on him . . . he should have known from previous conversations with tower that there was traffic on 28L. . . .

* * *

Aircraft A cleared for ILS to runway 25L. ATIS info, 8 broken 1-1/2 smoke and fog. We had the runway at about 500 ft; visibility was about a mile. Landing was routine; rollout was to the high speed exit opposite the XXX airline terminal. Tower cleared out aircraft, A, to cross 25R, "Ground .75 on other side." My first officer's response was "Roger." So I continued my roll across 25R. (The clearance was verified about the time we entered the high-speed from 25L.) As the nose of our aircraft entered the edge of 25R, aircraft B, taking off, passed over us. The clearance could not have been more than 50-75 ft. We had heard no radio clearance or conversation whatsoever about activity on 25R, so aircraft B either took off without clearance or the runways were being handled on separate frequencies. . . . I must accept responsibility for trusting the clearance to cross 25R without asking my copilot to verify that we were clear by looking to the right up runway 25R.

Problems relating to airport lighting and markings appeared in seven reports of pilot- and controller-initiated occurrences.

Aircraft A was taxied to runway 33L via the outer terminal taxiway to hold short of Charlie taxiway. When next observed, the aircraft was stopped on the centerline of runway 22R, at the approach end of runway 4L. At this time aircraft B was starting to rotate on runway 22R about three-fourths of the way down the runway. Aircraft A was instructed to taxi straight ahead and clear the runway immediately. Controllers feel that field lighting and poorly marked taxiways are the prime reasons for this recurring problem. . . .

* * *

I called for progressive taxi instructions, notifying the tower that I was unfamiliar with the airport. The controller cleared the aircraft to runway 34R. I taxied south following the blue lights until the lights turned west toward the runway, then turned west, held short, and did my run-up. I called "Ready for takeoff," and the tower cleared me into position to hold. As I took the active,

another light aircraft passed me on its takeoff run, deviating to the west side of the runway; our wing-tip clearance was about 20–30 ft. I asked what had happened and the tower told me that they thought I was at the end of the runway and thus would be behind the departing aircraft.

I am responsible for the safe operation of my aircraft, and that includes not taxiing into the path of a departing aircraft, even if cleared by the tower. However, as one high-ranking GADO official once said to me, "A pilot sometimes gets a lot of help going down the tubes." First, I too thought that I was at the end of runway 34R. I had asked, "Do I just follow the blue lights south to the end?" Ground control said, "Yes." When I finally turned west on the taxiway, there were no more blue lights to the south, only to the west (leading to an intersection). As I turned west on the taxiway, I saw a sign pointing to R34R and R32. . . . As I held just east of the hold line, I could see a large painted area on 34R which appeared to be the numbers. . . . When I received clearance into position, I looked to my left. It may be difficult to believe that I looked and did not see an aircraft coming toward me, but as I reconstruct the matter, I looked up for an aircraft on final . . . I should have seen the other aircraft, and I bear the responsibility for not having seen it . . . however, the tower certainly cleared two aircraft to operate on the same runway at the same time. . . .

* * *

I was the captain on flight A departing Atlanta. We were cleared to taxi to runway 27L by runway 15 to hold short of runway 26 and 27R and to follow an aircraft B. Aircraft B ahead held short of 26 and was then cleared across. I asked the first officer to request clearance to cross with the other aircraft; we were advised to hold short. We were holding short of what I believed at the time to be the east-west taxiway. While holding, I saw landing lights on an airplane C in position at the east end of runway 26. At that time I realized I had inadvertently crossed the E-W taxiway and was very close to runway 26. I believed we were too close and immediately had the first officer alert ground control of our position and need to cross. We expedited across the runway when clearance was received. . . . On runway 15 in relation to the east-west taxiway for runway 26 there is a very large concrete area to the east of the position I was holding . . . much of this area is either not lighted or inadequately lighted with respect to designating the edge of the runway. . . . This area did not provide an adequate reference. . . .

Other airport problems were cited in ten cases. They included inadequate taxiways, taxiways too close to runways, parallel runways too close to permit holding between them without intruding on one or the other, and inadequate maintenance. Two reports of pilot-initiated occurrences cited obstructions to tower visibility; one is quoted here.

I was doing touch-and-go practice, and was cleared for touch-and-go runway 31. I was informed aircraft B, a wide-body, was to hold short of runway 31. He was taxiing from the ramp to runway 6R for takeoff. At any rate, he did not hold short. Fortunately, I was practicing zero flap landings, so my airspeed was higher than usual. As soon as we concluded aircraft B was not going to stop, I

applied full flaps, full power and made a hard climbing right turn. I missed B by less than 100 ft . . . part of the problem is that the personnel in the old tower cannot see the activity on runway 31 north of runway 6L, so they were more or less helpless in this situation. . . .

In summary, pilot-initiated occurrences often involved performing some maneuver without clearance (46 of 65 cases). This was often associated with a coordination problem within the cockpit or between flight crew and ATC (22 of 46). Pilot disorientation or confusion was noted in 12 of 65 occurrences.

Controller-initiated occurrences— These occurrences usually involved failure to insure that separation would exist (74 of 89 cases). In 45 of the 74 cases in this category, there were associated coordination problems (with the aircraft in 16 cases, within the tower in 26 cases, and between tower and approach control in 3 cases). Inadequate information transfer within ATC is strongly associated with controller actions involving failure of separation.

Inadequacies in coordination among tower personnel (usually between local and ground controllers) were associated with serious problems relating to runway incursions. Note in the first two reports the role of visual monitoring. In the third report, visibility restrictions were a factor, though there is no question that visual recognition of the conflict led to its resolution.

At about 1215 hours, I was cleared for takeoff on runway 25. As I approached the intersection of runways 25 and 15 during my takeoff roll, aircraft B, which was previously facing west, turned toward runway 25 to taxi north. As B's nose neared the centerline of the runway my position was 100 ft or less from the aircraft and closing with a speed of 55–60 knots. At this point I rotated (at a slightly premature speed) and lifted off. I turned right at about 10 ft of altitude, avoiding the nose of the other aircraft by 10–20 ft. I contacted the tower and was informed that B was cleared by ground control and that the ground controller was in error . . . as a secondary cause, the crew of the air carrier aircraft should have looked both ways prior to taxiing onto runway 7-25.

* * *

We landed on 23L at (a foreign airport). Tower cleared us to turn off on taxiway B and contact ground control. Ground control cleared us across runway 23R to our gate via taxiway A. My first officer rogered and we started to cross 23R. He hollered "Stop, somebody is takeoff!" or words to that effect. We stopped and a corporate jet passed right in front of us. Had we moved 10 ft farther the smaller jet would have hit us. It appeared he was just breaking ground as he passed us. . . .

* * *

(From one pilot) We were a (four-engine jet) ferry, cleared to taxi from the hangar area to the northwest runway, 32L, via the active runway parallel taxiway for an intersection takeoff at T-1 . . . the weather was -X 2@ 3/8 fog, ceiling 1@VAR3@. On reaching the intersection we advised ground control and were cleared to tower.

On initial call, we were number one for takeoff and advised the tower . . . tower cleared us into position and hold. A short time thereafter, tower cleared another aircraft to land. I had taxied onto the runway and was about to make the 90° right turn when landing lights appeared on the left side. Visibility was restricted. I promptly added power to clear the runway instead of turning. I continued straight across onto the continuation of T-1. While waiting for the engines to spool up after throttle application a wide-body in a landing flare appeared with the landing lights on and as we cleared the runway while still moving the wide-body passed behind us.

I cannot say for sure how to detect the fact you have been cleared into position in front of a landing aircraft in restricted visibility especially at an airport with multiple runway operations. . . .

(From the other pilot) We were cleared to land by the tower when we reported Romeo inbound. Weather reported 2 $\frac{3}{8}$ fog, RVR 3500 approach 3000 middle and end of runway. Copilot flying, approach normal. About 1,000 ft past threshold at the point where engineer called 30 ft altitude and at the point where I was taking control for touchdown, I saw a heavy jet in the middle of the runway. I applied full power for go-around and started climb. Saw the other airplane clearing so cut power and landed. Our approach speed was 145 knots, weight at landing 478,000 lb.

One coordination problem involved a shift change in the tower.

The visibility was RVR 1200; we had takeoff minimums and were holding short on the taxiway. We called ready for takeoff and received a takeoff clearance. I spooled the engines and started to taxi. Just as we started to move I caught a glimpse of an aircraft passing by and disappearing into the fog on 35R, the runway on which we were cleared for takeoff. I checked with tower; he apparently was taken aback by the event and was unaware the aircraft existed. He did not have him on radar . . . somehow the aircraft, on a Category II approach, had gotten lost in the shuffle of changing shifts. . . .

Phraseology problems were associated with five runway incursions. Examples are shown here.

Aircraft A requested departure clearance on runway 4. I cleared aircraft A for takeoff. Aircraft B was advised to taxi into position and hold runway 7 for traffic departing runway 4. Aircraft A called again for verification of departure clearance. Aircraft A was advised, "Cleared for takeoff, minimum delay, traffic awaiting departure on runway 7." I was then momentarily distracted and when I looked up both aircraft A and aircraft B were airborne and rapidly converging. I gave aircraft A a right turn to avoid traffic. Traffic separated and no further conflict occurred . . . the aircraft came within 500 ft of each other . . . I believe a contributing factor was fatigue. Two of us have worked the day shift without a break; even lunch had to be eaten in position. . . . I am thoroughly bushed, and I still have 1 hr to go. . . .

* * *

Airline aircraft A was told to round a corner of the departure runway and not to plan on stopping. Traffic, aircraft B, was landing on an intersecting runway. I turned my head to look at another of my departure runways and A departed. The landing aircraft stopped short of the runway being used for departure and the pilot called for an explanation . . . better phraseology should have been used to A about holding in position.

ATC and controller procedures were associated with specific problems in 11 reports, not all involving controller-initiated occurrences. The difficulty posed by a hold-point very close to a landing runway was cited in two reports.

After landing on runway 9, tower cleared us to turn off the runway via Romeo and contact ground control. . . . Upon turning off, the after-landing checklist was accomplished. As I adjusted the frequency and volume for ground control, I heard them calling us to hold our position. We were approximately 1,000 ft from the turnoff point when the captain and I heard ground calling us and when we stopped we were in the middle of another active runway (22) and a light airplane was flying at, up and over us . . . the turnoff of runway 9 to 22 is a very short distance and narrow, requiring the full attention of the pilot taxiing. There is no ATIS to warn the crew of multiple active runways and I do not recall the approach or tower controllers advising of this . . . the tower supervisor after the incident advised me that this had happened several times previously. . . .

* * *

After instrument approach, on landing rollout runway 5L, tower instructed aircraft to turn off on runway 10. Instructions were acknowledged by first officer. We changed to ground control and were told to hold short of taxiway N. Taxiway N occurs near the turnoff so aircraft was almost through N at the time of the transmission. Ground control told aircraft both he and tower had instructed the aircraft to hold short of N. . . .

Simultaneous intersecting ILS approaches were cited in one report.

Aircraft A was established on the ILS course for runway 7. We were advised by approach control of traffic at ten o'clock, 4 miles, on an ILS for runway 10. Approximately 2 minutes later I inquired about the traffic and was informed he was "ten o'clock, 3 miles." The first officer informed me that the outer marker light had started blinking just as we broke out of the clouds and saw the traffic, which seemed closer than 3 miles. The distance between the outer markers for runways 7 and 10, according to the scale on the approach plate, is just under 2 miles, but the issue is not whether we were 3 miles or closer. The real issue is that both aircraft were inbound on intersecting localizer courses. To compound the problem, both aircraft were at similar airspeeds. The use of simultaneous ILS on intersecting courses might seem to be efficient and safe to ATC, but it is potentially hazardous. Because of the converging courses which it inherently provides, all the ingredients for a midair collision lie in wait for a triggering last-minute event: a simple controller distraction, or a communications failure, or radio congestion. Procedures should be fail-safe. . . .

The control of intersecting patterns by different control positions was discussed in one report in this sample (other ASRS reports have also cited this problem).

I was flying airline aircraft A on the above date. Tower issued takeoff instructions and we broke ground off runway 35R . . . at that time I saw corporate jet B cross directly in front of me, having taken off from runway 27. Upon reaching a safe altitude, I asked the tower operator if he was aware that the aircraft were taking off simultaneously. He said "No." Subsequent inquiries . . . indicate that the tower personnel felt nothing of significance occurred. I feel that it was highly dangerous. . . .

A specific procedural problem was cited in several reports, all of which mentioned difficulties associated with simultaneous use of intersecting runways. The issue in these and other reports concerning these procedures is what happens when a problem is encountered by one or the other aircraft if the procedures leave little room for a "fall-back" position.

Airline captain was cleared to land on runway 14L and at the same time tower cleared another airline aircraft for takeoff on intersecting runway 27L. We were given no warning by approach control or tower of the departing aircraft on the intersecting runway. If we had to make a go-around it would have been very close. We had made a long landing to save taxi time, and had to use heavy braking to avoid the intersection. . . .

* * *

Tower cleared aircraft A to land on runway 27L and aircraft B to land on 32L at the same time. The runways intersect. Had aircraft A not been able to hold short of the intersection the two aircraft would have collided. When questioned about the practice the tower answered, "I've been directed to use the runways in this manner."

* * *

As we were cleared to land on 14L the tower asked us to expedite through the intersection of 4L and we agreed. On touchdown we experienced difficulty with the aircraft due to very poor braking action and crosswinds. With this difficulty we did not, in fact, expedite through the intersection. I believe the tower was not observant as they cleared another aircraft for takeoff on 4L before we were through the intersection. . . . I personally believe that this runway configuration is undesirable unless more attention is paid, and the landing aircraft should not be questioned. One week previously, I experienced the same problem departing on 4L. I aborted takeoff due to an aircraft in the intersection of 4L and 14L.

* * *

We were cleared to land on 27R. Another aircraft was cleared for landing on 22R to hold short of 27R. Both aircraft touched down at nearly the same time. We landed normally on 27R but could not tell for certain that the aircraft on 22R would in fact be able to hold short of the intersection. He did not ever come to a

full stop because he was playing his taxi to expedite traffic (there are no turnoffs on 22R). We braked to a slow taxi to be certain of our clearance and so that we could stop if he couldn't. Tower immediately told us to expedite off the runway for landing traffic. After we turned off a twin and a tri-engine jet touched down on the two runways with the same result, only the trimotor braked heavily. This operation is unsafe; it adds too many additional variables during the critical landing phase.

Training was involved in five controller-initiated occurrences. A typical example follows.

Aircraft A landed on runway 12, then aircraft B was told to taxi into position and hold runway 12, which he did. Aircraft C was on a 3-mile dog-leg to final for 12 at this time. By the time aircraft A cleared the runway aircraft C was on 1-mile final. When aircraft C touched down aircraft B was 3,000 ft ahead of him and just lifting off. Controller training was in progress at the time and the trainee apparently didn't realize it would be that close. By the time I decided to send aircraft C around it was too late; he was already committed to land. The pilot remarked that he should have gone around, but he did not. The trainee should either have sent him around or not taxied B onto the runway but did not. I should have sent C around but I did not. None of us reacted to this situation as we had been trained to and the result was less than standard separation.

Several of the reports in this sample described situations in which a go-around was initiated by the pilot because of a perceived threat to separation. Such an action was taken in 17 cases. In at least some of these, the action produced new problems, although it obviously averted problems in other cases.

We were cleared for immediate takeoff from 'in position' on runway 31 and began our roll without delay. Aircraft B was on final approach to runway 22. Our spacing was slightly less than what we've been used to at this airport, but we felt that we had more than adequate separation. During our takeoff roll aircraft B initiated a go-around. We crossed the runway intersection at about 300 ft AGL and at that time B appeared to be near level with us and perhaps over the approach lights. The fact that he pulled up and possibly accelerated put our aircraft in closer proximity than if he had continued his approach and landed. We would not classify this as a near miss but the potential exists in this situation.

* * *

Aircraft A reported to tower on downwind. I cleared A to land. Aircraft B called for takeoff. B was cleared for takeoff, then cleared for immediate takeoff and given traffic, aircraft A, 1-mile final. A declared the approach too close to departing traffic and went around on the right side of the departure. In my opinion if A had continued his landing I would have had minimum departure separation. However, due to the pilot's initiation of a go-around he reduced longitudinal separation and passed B at midfield.

In 20 occurrences, both the pilot and the controller erred in some manner. Eight, or 40%, of these occurrences involved a near collision. These reports were therefore singled out for

examination. It was found that these occurrences, like the others in this study, involved a variety of factors. One factor noticeable in this subset of reports, however, was very tight spacing of traffic (in eight cases) which produced problems when not all participants behaved as expected. Two examples follow. In both cases, one or more of the pilots, as well as a controller, contributed to the situation.

Aircraft A, landing 4R, was instructed to roll to the end. Aircraft B was in position runway 8L awaiting the landing A to roll through the intersection. Anticipating separation, the controller instructed B to start a fast taxi since there was a heavy aircraft C on short final for 8L. Aircraft A slowed and tried to use a diagonal taxiway that saves time to the gates. Controller instructed A to cross the intersection without delay; A did so and takeoff clearance was given to the fast-taxiing B. This was not a safe operation by the local controller and will not be tried again. This airport is extremely hard to work because of crossing runways and numerous intersections for takeoff. . . . In the above incident the two aircraft missed by 300 ft or so; too close. . . .

* * *

Transport aircraft A taxied out and was holding for takeoff. Another flight had landed and was still on the runway. Aircraft A was cleared for something and the transmission ended. Only a couple of seconds later, A was cleared into position and cleared for takeoff. Just as we were about to start our takeoff an aircraft B who was on final said he was going around. As I made the last 90° turn onto the runway I saw lights and he appeared about a mile or so out on final. When he elected to go around I elected not to start my takeoff roll as it appeared that from his position and my takeoff and climb we would be very close (visibility was 1 to 1-1/2 miles, ceiling about 300 ft). Since I had not started to take off, and since aircraft B was not going to land, I made a right turn back off the runway. Aircraft B said he could land but the tower told him to go around, then immediately told him to go ahead and land. Aircraft B advised that he would have a moment earlier but he could not at that time. In aircraft A, we advised that we would continue with our takeoff and that we were starting our takeoff roll. The tower advised to turn left and taxi clear of the runway.

There is no taxiway off to the left of the runway except at the very end so we did a quick turn and cleared the runway on the east side. As we were clearing, an aircraft C was told to go around. The result of this incident was at no time a hazardous condition, but it did result in two aircraft having to go around . . . air traffic was very heavy at the time . . . during these conditions radio communications are so congested that it leads to misunderstandings and confusion on the part of both the pilot and the controller. Expediting the situation only adds to the confusion. . . .

In summary, controller-initiated occurrences generally involved failure to insure that separation would exist. An important corollary factor was a failure of coordination with other tower positions. Training may have been a factor in a few cases; procedures may also have been a factor in some. Tight traffic spacing appeared to be a factor in cases in which a flight crew error compounded the controller's error, or vice versa.

Other factors— A number of other factors were also present in and pertinent to these occurrences. Environmental factors were cited in 12 cases. Five of these involved restricted visibility; in one, the controller's alertness averted a problem.

Aircraft A requested taxi clearance from the south ramp to the active runway. Visibility was 3/16 mile in ground fog; taxi instructions were given and the RVR for runway 10. The aircraft advised he was "slightly unfamiliar" with the airport layout and detailed instructions were given. In his taxi, he was required to cross the active runway at midfield. Aircraft B was holding in position for departure and I requested A to report crossing runway 15R at taxiway F, a point that is clear of the active runway 10. From past progress reports, after a sufficient lapse of time, I asked A for a confirmation of his position and was told he had cleared the checkpoint. I had a ground vehicle holding clear for the A on yet another taxiway and was awaiting his report of sighting A. Again, from A's past reports and the time lapse, he should have passed the ground vehicle, but had not. Unsure of his position, I elected to advise local control to hold his departure. Upon further inquiry, the pilot of A admitted he was not sure of his location. B was held until A reported sighting an airline ramp, a point known to be clear of the active. . . .

In a second report, a late hand-off and a missed approach presented the controller with a potentially critical situation.

Aircraft A was on a VOR approach to runway 13L and aircraft B was departing runway 31R with a right turn out northeast-bound. Approach control did not give the tower a hand-off on the VOR approach. The weather was marginal with low ceiling and the VOR approach called well inside the normal hand-off point, after the tower controller had released the VFR 31R departure, not knowing about the opposite direction IFR aircraft. Due to the ceiling coming down, the IFR aircraft executed a missed approach. The tower controller separated the aircraft visually by seeing aircraft B and climbing aircraft A. . . .

Intersecting runway operations in wet weather caused another problem.

Airline aircraft A on short final for landing on runway 12L made a touch-and-go in order to pass over aircraft B who, after landing on runway 17, could not hold short of the intersection of runway 12L. Runway 17 intersects 12L 3,000 ft from the approach end. The runways were wet at the time.

Several reports discussed controller visual problems; in this case, night compounded the problem.

Aircraft A was cleared to land on runway 16 with aircraft B cleared for touch-and-go on intersecting runway 30R. At the time both clearances were issued, judgment and experience indicated standard separation would exist. It did not, but due to the angles involved, this less than standard separation situation was not apparent until it was too late to do anything about it. The situation occurred at night, with both aircraft landing toward the tower. As a result, both distance and

speed determinations are extremely difficult. . . . The aircraft involved were not that close, but it was potentially unsafe. A bright display would have helped here. . . .

Frequency congestion was a factor in six reports. It was usually cited as a factor that made it more difficult to confirm unclear or partially missed instructions. Language problems were cited as a factor in four runway incursions; similar flight numbers were a factor in one case. Workload was cited as a contributing factor in five occurrences, fatigue as a factor in one.

When this study was initiated, it was the opinion of the authors that surface vehicles would be found to be an important facet of the runway incursion problem. This proved not to be the case. Motor vehicles were a factor in only 8 of 165 occurrences.

The driver of a vehicle was the initiator of six of the occurrences. In three cases, the driver crossed an aircraft movement area without clearance; the other three involved disorientation or confusion as to his position on the part of a driver. The outcome was a collision in one case, less than safe separation in one, a recognized error in two, and no conflict in two. In one case, a motor vehicle wandered onto an airport from outside; the other cases involved airport service vehicles.

Motor vehicles have been a persistent problem at certain airports that have deficient security fencing; however, they did not appear to be a frequent problem in this sample of reports from controlled airports.

General discussion— What, in summary, can be learned from these data? In particular, do the data suggest any measures that might assist in solving the problem of runway incursions, if these occurrences do represent a problem?

First, while we are uncertain as to the magnitude of the problem, it seems certain that a problem exists. That some of these near collisions were not accidents instead appears to have been due to chance alone (the occurrences in which no recovery action was taken are an example).

Given the existence of the problem, how may it be characterized? The problem appears at first glance to be twofold. One aspect involves pilots who do not have, or who misunderstand, a clearance prior to executing a maneuver. The second aspect involves controllers who fail to insure that separation exists and that it will continue to exist before they issue a clearance. Both problems, however, appear in a large number of cases to involve a common factor: lack of information. In the case of the pilots (and the vehicle operators), the information they lack is a timely, unambiguous clearance. In the case of many of the controllers, the information relates to their or other traffic, or about the intentions of pilots (or drivers).

In many of these reports, it is clear that considerable pacing stress is involved. The pilot has schedule pressures, the need to conserve fuel, and the constant knowledge that he cannot "get there by sitting here." The controller's problem is more pervasive; he must move traffic, simply because he knows there is more coming. One of these reports is illuminating, for it illustrates that controllers will sometimes go further than perhaps they should to provide whatever services are requested of them.

Aircraft B executing practice ILS 31L approach to a full stop . . . aircraft A advised on left base with B in sight. Local control cleared A to land 31R. . . . local control had other distractions and did not continue to watch A . . . radar was not

painting the aircraft. . . . A stated that an aircraft was on the runway; local control did not observe an aircraft on 31R and checked 31L. I observed A about 20 ft AGL about to land on top of B. I told A to go around. As A started his go-around on 31L additional traffic was C on short final on runway 36. I told C to make an emergency pull-up to avoid A. Contributing factors: poor radar reception and only one local control position. Just prior to this incident I had worked 107 operations using three runways . . . one local controller has difficulty observing all of the critical areas for three different traffic patterns. . . .

Frequency congestion, shortcuts, nonstandard phraseology, unpredictable and unannounced flight crew actions, visibility restrictions, and other factors all play a part in this problem, but it appears that the information transfer problem, for whatever reasons, is at the heart of a substantial part of it. Given that over half these occurrences involve an aircraft taxiing, and therefore able to stop almost at will, it is suggested that it should be productive to examine closely ways to insure that taxiing aircraft (and motor vehicles) are under all circumstances absolutely certain of what they are supposed to be doing.

There are three facets to this part of the information transfer problem; each is important, but the relative importance will vary as a function of geographic features, airport layout, and procedures in various locations.

Standard operating procedures for taxiing, either system-wide or airport-specific, will help to insure compliance with desired patterns of behavior in most cases, if they are known to all users and if they are simple enough to be understood. Although steps have been taken to clarify taxi clearance limitations, it appears from the number of occurrences involving this factor that additional attention might be helpful.

Taxiway lighting and markings appear to be a problem at a number of locations, especially during periods of construction or repairs. While many improvements have been made in signs over the past several years, markings, especially at night, still appear to represent a deficiency. The problem is most acute at the junctions of taxiways with runways.

Clearances were a problem in a number of reports, particularly when ground control frequencies were congested. The dangers of nonstandard or abbreviated clearances are clear; maintaining clearance discipline under severe time constraints, however, is a constant struggle. One pertinent location-specific situation noted several times in the study involved being directed to "follow another aircraft," then uncertainty as to whether to follow the other aircraft across an active runway. Some pilots did, some pilots did not, and some pilots queried ground control for clarification. It is this sort of ambiguity the system should seek to avoid.

Lack of clearance for takeoff or landing was noted in 14 reports. This can hardly be due to a lack of knowledge of the requirements for such a clearance. Data regarding the four aircraft that landed without clearance indicate two were not in contact with the tower; the reasons why the other two landed are unknown. In the case of takeoffs without clearance, however, a pattern was more evident. In 7 of 10 cases, an aircraft took off immediately after a takeoff clearance was delivered to another aircraft. One case involved similar flight numbers, one involved an incomplete (no aircraft identification) repeat of a previously issued takeoff clearance, after which two aircraft took off simultaneously on intersecting runways. In the other cases, the reason for takeoff was

unknown in one, a probable language problem in a second, and a crew member's misinterpretation of a question from the other pilot in the third.

The tone of several of these reports suggests that pilots already in position and awaiting takeoff clearance may have heard what they expected to hear, without recognizing that the clearance was for another aircraft on another (or even the same) runway. It is in this subset of cases that devices for visual confirmation of takeoff clearance would be useful, but it is also suggested that with the multiple-runway and intersection takeoff operations, which characterize nearly all of our busier airports, a heightened level of caution on the part of pilots, perhaps accompanied by a readback of the flight or aircraft numbers in acknowledgment of the clearance, might accomplish the same thing.

It is clear that problems in coordination between local and ground controllers are a factor in a substantial number of runway incursions. It is equally clear that pacing stress is a contributing factor in these and probably in other failures of coordination. Though a recent FAA directive mandating verbal coordination prior to permitting the crossing of one of two active parallel runways may be of help, a recent ASRS report describes the difficulties associated with implementing this directive at an extremely busy VFR tower serving a multiple parallel runway operation.

Conclusions

The following conclusions are drawn:

1. Incursions of aircraft onto runways at controlled airports represents a significant safety problem
2. An important factor in both pilot-initiated and controller-initiated runway incursions is failure of information transfer among the relevant system participants
3. Taxiing aircraft, a major contributor to these occurrences, represent the most effective single point of attack on the problem, if ASRS data are representative.